RESEARCH PAPERS

Comparison of Flavor and Physical Properties of Foam Spray-Dried Whole Milks Prepared from Concentrates Foamed with Air and with Nitrogen

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Abstract

Foam spray-dried whole milks prepared from concentrates foamed with nitrogen, air from cylinders, and air from a plant-installed compressor were compared regarding certain physical properties and flavor, initially and after oxygen-free storage for 3 and 6 months at 4C. No evidence was found for variations in either physical properties or flavor attributable to the foaming gas used. It is concluded that air can safely be substituted for nitrogen in preparing foam spray-dried whole milk.

Introduction

Foam spray-drying of dairy products has been successfully applied to acid Cottage cheese whey (4), skimmilk (1), and whole milk (3). In this process, a gas is injected under pressure into the concentrate between pressure pump and spray nozzle. With release of pressure in the drier cone, spray droplets are expanded to particles of lower density and greater surface area than those formed from concentrates without gas injection. Advantages of this process include improved dispersibility of the product and more efficient water removal during drying.

Plants now manufacturing foam spray-dried skimmilk or whey use air compressed in locally installed compressors for foaming. To minimize possibility of oxidation, inert gas has been used in manufacturing foam spray-dried whole milk. This product is then packed in cans with an oxygen-scavenging system containing 95% nitrogen, 5% hydrogen, and Pt catalyst (10). Initially, .02% oxygen in the gas is quickly reduced to .001% or less, but complete removal of oxygen from the powder's interior is much slower. In samples packed without a catalyst, oxygen in the gas increased for 1 week to a maximum of about 1% (5).

The likelihood of off flavors being formed by oxidation during this diffusion period should be a function of the amount of oxygen within the powder. If inert gas is used for foaming, there is no flavor problem. If air is used for foaming, more oxygen conceivably could produce off flavors.

Increasing interest in manufacturing foam spray-dried whole milk makes it desirable to know whether more expensive inert gases can be replaced by air without adversely affecting the flavor of the product. Consequently, experiments were conducted in which dried whole milks were prepared from concentrates foamed with nitrogen from cylinders, air from cylinders, and air from a plant compressor. Flavor was evaluated by a 10-man taste panel initially and after 3 and 6 months of storage at 4C. Certain physical properties are included in this report, as the gas used for foaming can grossly affect structure of dried milks (2).

Experimental Procedures

Foam spray-dried whole milks were prepared by the procedures of Hanrahan et al. (3), modified by the addition of charcoal filters at the drier air inlet, and by cooling the powder with liquid nitrogen prior to collection (6). Milk was standardized to 3.3% fat, concentrated to 50% total solids, and the concentrate sprayed after addition of a foaming gas through a 1.02 mm nozzle at 100 atmospheres pressure. The foaming gases were added to the concentrate at 130 atmospheres at 7 liters per kilogram, producing powders with a bulk density of about .25 g/ml. Samples for later tasting were packed in cans containing an oxygen-scavenging system (10) and held at 4C.

In each experiment, 3 powders were prepared from the same concentrate by foaming with nitrogen from cylinders (ultra high purity grade),[1] locally compressed air[2,3], and air

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[1] Air Products and Chemicals.

[2] Ingersol-Rand Type 30 Model 223 compressor with oil trap and added charcoal filter.

[3] Trade names mentioned for identification, implying no endorsement.

TABLE 1. Composition and physical properties of spray-dried whole milks prepared from nitrogen and air-foamed concentrates[a].

Composition or physical property	Foaming agent					
	Nitrogen		Locally compressed air		Air from cylinders	
	Range	Average	Range	Average	Range	Average
Moisture (%)	2.4-3.2	2.6	2.0-2.8	2.4	2.0-2.8	2.5
Fat (%)	25.7-27.6	26.7	26.4-27.6	27.1	25.8-27.7	26.7
Free fat (%)	17.6-31.7	24.5	19.4-33.5	25.0	18.9-37.7	25.7
Bulk density (loose) (g/ml)	.18-.22	.20	.17-.22	.20	.17-.25	.21
Bulk density (tamped) (g/ml)	.25-.29	.27	.23-.27	.25	.24-.27	.26
Dispersibility (%)	76-83	80	75-84	79	74-85	79
Sinkability (%)	6-10	7	6-9	7	6-8	7
Solubility index	.1-.1	.1	.1-.1	.1	.1-.1	.1

[a] Calculated from data of 4 experiments.

from cylinders (breathing quality grade)[2]. Sufficient powder was discarded between each collection to clear the drier of the preceding product.

For flavor evaluations, the powders were reconstituted with water and judged as whole milks by a 10-man panel using a scoring range of 31 to 40 (7). All samples were tasted blind, in duplicate, with no more than 10 samples including duplicates presented at one time. Composition and physical properties were determined as follows: moisture by toluene distillation, fat by Mojonnier ether extraction, solubility index by American Dry Milk Institute Method, bulk density (9), dispersibility (9), sinkability (9), free fat (8).

Results and Discussion

Physical properties data are listed in Table 1. The solubility index was the same for all powders. Other properties varied. Differences associated with type of foaming gas were small. Those occurring in different experiments (range of values) were larger. The data indicate that air can be substituted for nitrogen in the preparation of foam spray-dried whole milk without adversely affecting the product's physical properties.

Data in Table 2 summarize the flavor evaluation of the dried milks. Each taste panel score is an average of 20 flavor evaluations (10 judges tasting duplicate samples). Averages and ranges in this table are derived from taste panel scores of 4 experiments.

In a total of 720 flavor evaluations, 7 samples were oily. Five of these were from concentrates foamed with locally compressed air. This suggests a need for precautions against contamination of the concentrates from off-flavors originating in the compressor. The other two oily samples were both from concentrates foamed with nitrogen. These criticisms could have been a flavor carryover from adjacent oily samples.

Flavor score differences associated with replication are larger than those associated with type of foaming gas. The latter appear to be so small as to be without practical significance. The data were subjected to analysis of variance to test the hypothesis that the means of the three powders prepared with different foaming gases are equal. Total variance was

TABLE 2. Comparative flavor scores of spray-dried whole milks prepared from nitrogen and air-foamed concentrates.

Foaming agent	Flavor score [a]					
	Initial		3 Months		6 Months	
	Range	Average	Range	Average	Range	Average
Nitrogen	36.5-37.1	36.8	35.9-36.9	36.6	35.0-35.5	35.2
Locally compressed air	36.4-37.1	36.7	36.0-37.0	36.5	34.6-35.6	35.0
Air from cylinders	36.3-37.1	36.8	36.0-36.9	36.5	34.8-35.5	35.2

[a] Calculated from panel averages of 4 experiments.

TABLE 3. Analysis of variance.

	Degrees of freedom	Sum of squares	Mean squares	*F*-Value
Time	2	38.547	19.274	153.03
Experiment	3	.964	.321	2.55
Type of foaming gas	2	.159	.079	.63
Error	64	8.061	.126	
Total	71	47.730		

partitioned into components due to experiments (4), powders (3), and time periods (3). A summary of the analysis is in Table 3. The very large *F*-value associated with storage time is in accord with the well-known fact that lactones formed during storage affect the flavor of dried whole milk. The *F*-value of 2.55 associated with replication of the experiment indicates a variation significant at the 10% level. It seems likely that this results chiefly from taste panel variations at different sittings. The very low *F*-value of .63 is consistent with the hypothesis that the three types of powders have equal means.

These results indicate that no flavor-detectable oxidation was induced by air as a foaming gas. It is concluded that air, if pure, can replace nitrogen as a foaming gas without adversely affecting the flavor of dried whole milk.

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